Post & Wright

Tests of Traction Engines

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TESTS OF TRACTION ENGINES

...BY...

RAEBERN HENRY POST
AND
WARD ELLIS WRIGHT

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
OF THE
UNIVERSITY OF ILLINOIS
PRESENTED JUNE, 1904

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May 27, 1904 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

RAEBERN HENRY POST and WARD ELLIS WRIGHT

ENTITLED TESTS OF TRACTION ENGINES

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

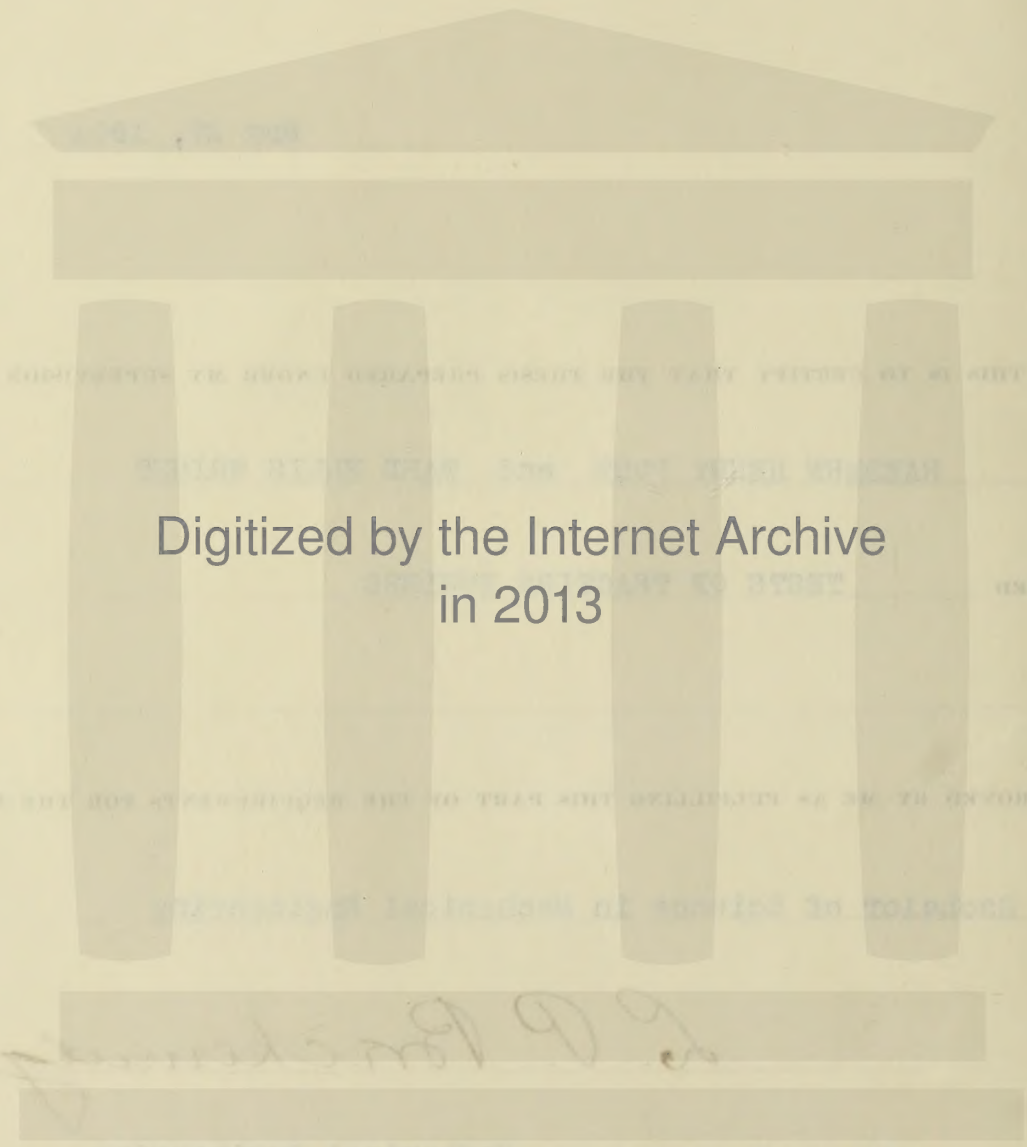
OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

66202

ENGINEERING LIB



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Traction Engine Test.

Out Line of Thesis.

This thesis, a series of tests on a 16 horse power traction engine, is divided into six parts as follows:

I. Existing Conditions.

II. Description of Apparatus.

III. Manner of Conducting Test.

IV. Methods of Calculations.

V. Log sheets and Curves.

VI. Discussion of Results.

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Introduction

Traction or farm engines until about 1870 were all of the simple single cylinder type. At this time the road locomotive was introduced and it was immediately seen that the engines at hand were unable to supply the additional power necessary to operate the latter. The demand for increased power with out additional weight on the road led to the introduction of the two-cylinder simple engine and later to the compound engine.

It is not the purpose of this thesis to show the comparative efficiencies of the two types, as the former type is rapidly becoming obsolete, but rather to show the efficiency of the compound type under actual working conditions.

I Existing Condition

The traction engine was built in a small frame building, built expressly for the test, situated on the south farm of the University of Illinois Champaign Illinois.

The Engine is a Reeve Cross compound rated at 16 horse power. It has a link attachment by which it can be changed into a simple double-cylinder type. Owing to some difficulty of the valve the low pressure cylinder were cut out almost entirely when the test were taken in order to change the engine to the simple type. The tests here in shown were made with the Engine running compound, so that the trouble mentioned above does not enter into the results shown.

The adjustable reverse and cut-off mechanism of the Stephenson link type is

the range of admission or cut off can be varied from $\frac{1}{4}$ to $\frac{3}{4}$ stroke in both directions.

The steam from the high pressure cylinder is exhausted into a receiver and from this it enters the low pressure cylinder. Then it is exhausted into a feed water heater, located directly beneath the two cylinders, from which it passes to the smoke stack.

The boiler is jacketed, having a $\frac{3}{4}$ inch asbestos lining with a sheet steel covering bound in place with $\frac{1}{2}$ inch brass bands.

The engine is fitted with two injectors, one connected with the feed-water heater, the other injecting directly into the boiler. The former was used exclusively during the test-made.

The feed-water was taken from a hydrant connected to the water mains of the University and located in the engine house.

Dimensions of Engine and Boiler:

Diameter of high pressure Cylinder	7"
" " Low " "	10 1/2"
Stroke of Piston	10"
Rated Horse Power - traction	16
Revolutions per minute	225
Diameter of Steam pipe	2 1/2"
" " Exhaust "	3 1/2"
Diameter of Band wheel	40 1/2"
Face " " "	8 1/2"
Diameter of shell of Boiler	32"
Length of tubes in Boiler	72"
Diameter " " "	2"
Number of " " "	103
Height of fire box	37"
Length " " "	38"
Width " " "	25"
Area of Grate surface	7
Diameter of Stack	13"
Length of Stack	34"
Depth of Smoke box	35"
Area of tubes - transverse sectional.	90
Weight of Engine Pounds	13,500
Heating surface square feet	136

Length over all 192"
Width " " 92"
Hight " " 114"

Coal.

The coal used was part washed nut coal and part lump coal, all coming from the Jimmy Sidr mines located near Murphysboro, Illinois.

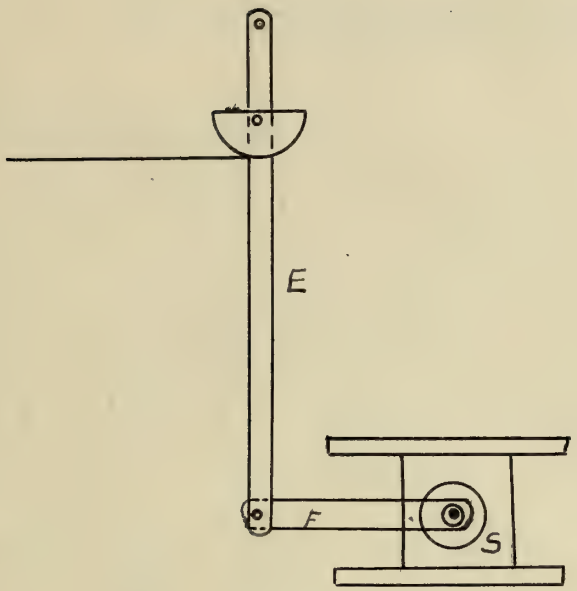


FIG. 1

II Description of Apparatus.

(a) Reducing Motion.

The form of reducing motion employed is shown in FIG. 1.

The connecting rod E is a straight bar of steel ¼ inch thick by ¾ inches wide and 20 inches long. It is supported by a cast iron frame attached to the engine cylinder and is connected at the cross head by link F, (¼" x ¼" x 6") to a stud fixed in the center of the cross head. The sector S is constructed of cast iron and has a groove in its circular edge for the cord to run in. This sector is fixed to the engine frame so that its center coincides with the center of the pivot upon which it swings. The following formula, taken from Goodeve's book on Steam Indicators, gives the proper radius for this sector as 7 inches.

The stroke x Diameter and length = radius of sector

Lever arm = 20"
Stroke = 10"
Card length = $3\frac{1}{2}$"
$\therefore \frac{20}{10} \times 3\frac{1}{2}$ = 7" vector radius.

Care was taken to set the reducing motion so that the bar which connects its lower end to the link pins was exactly below the tangential line of motion of the stud on the cross head as ~~it~~ which was that was at either end of stroke.

(b) Indicators

For indicator connections, the cylinders were tapped at 6 and 18 on top and at 12 and 24 in the cylinder head. Indicators at crank end were connected directly to the cylinders by two-way cocks and at the head end by $\frac{3}{4}$ inch pipe in the manner shown by the accompanying sketch, (FIG 2.)

Two Lynn and two Crosby steam indicators were used.

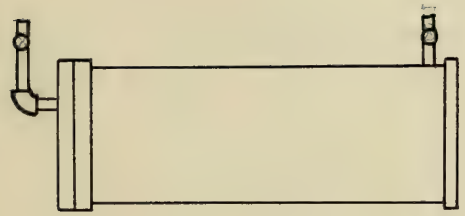


FIG. 2

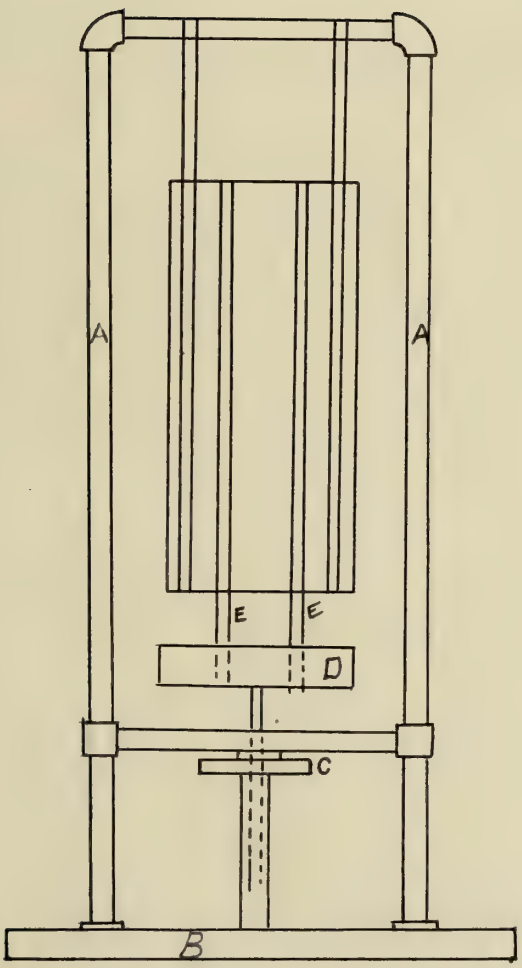


FIG. 3

sixty-pound springs were used on the high-pressure cylinder and thirty-pound springs on the low-pressure cylinder.

(C) Brake.

The brake employed is shown in FIG 3.

Frame A consists of 2 cast iron pipes fitted to an iron base, B. Hand wheel C either raises or lowers the rope clutch D which in turn loosens or tightens ropes E. Ropes E are held rigidly in place by grooved cross pieces fitting over the edge of the band wheel. These cross pieces are nine $1\frac{3}{4}$" x 2" x $8\frac{3}{4}$" crowned to fit the face of the band wheel and cored so as to receive $\frac{3}{4}$ of the circumference of the rope. They have steel finger pieces screwed on both ends. The brake arm, from center of shaft to center of rope, measures about four inches.

A platform, twenty seven inches high, was constructed under the sand wheel and upon this the water was placed, resting upon a pair of 1" timbers 6 inches wide.

In order to keep the sand wheel from heating a steady stream of water was kept flowing upon the inside of the rim. To waste the flow of water within a barrel was mounted about 4 feet above the floor level and water was siphoned from it to the wheel by the aid of a one inch rubber hose.

The sand wheel was not fitted with flanges and consequently water reached the face of the wheel, but in such small quantities that no appreciable difference could be noted in the action of the brake.

The sand wheel was operated by means of one and one half pounds of water per minute.

(d) Feed Water Receiver.

Feed water was fed to an oil fired heating coil Eaton weighing scales, suitably arranged for the purpose, and [illegible] water supplied from this source.

(e) Coal Receiver.

The coal was weighed in buckets and fed directly from these.

III Manner of Conducting Test.

Preliminary tests were made
the day prior to the final test runs
began, and every thing was put in
running order.

Four tests were made each
four consecutive days, two runs
per hour and two observations.
All runs complete, twenty-four
tests.

The work of the tests was
apportioned among four men.
Mr. C. L. Clarke and Mr. N. S. Loner,
as assistants took indicator
cards, Mr Clarke also taking T. & Pr.
Mr. Wright acted as fireman and
fireman and as such assigned coal
coal and water as used. He also
operated the fans, recorded coal
data, and took the necessary
temperatures.

The engine having been
brought to a normal condition
of running and operated a sufficient

length of time to be thoroughly heated in all its parts, and the steaming apparatus being adjusted and set to work, the height of water in the gauge glass of the main steam steam record and marked, with a measurement and by tying a piece of string around the glass. Condition of fire were carefully noted, the exact time of day was recorded and the test was then started. Temperatures were taken simultaneously every twenty minutes and the steam, water pressures in boiler, and gauge pressures were taken at the same time as the coal. Coal and water were weighed as used. The measurement of the coal began with the first firing after the test was started and continued to the last firing & four cleaning and burning down at the close of the test. Sample quantities of coal were taken from each measurement of coal

and the percent of moisture were determined by weighing the coal before and after drying.

Coal to be used were placed in a Fenny sack and kept under a vacuum heating stove for two weeks; The coal were thoroughly stirred every other days.

As a four stand, indicator cards were taken every twenty minutes. The load were constant at all times and no the cards were taken for the indicated four hour runs, every twenty minutes were observed this records.

Broke down were added to the hours desired from the card under test of the engine, and in the cases indicated by an induction motor attached to the main of the motor.

A way to test a constant load was kept on the cars. The kinds of the various tests were as follows:

Test	Load.
No. 1	200 lbs
" 2	265 "
" 3	285 "
" 4	170 "

The speed in revolutions per minute was taken with a speed counter every twenty minutes. The engine averaged 280 R.P.M during the four tests; which is within ten revolutions of the rated speed as shown by the Power Engine catalog.

When ever carbon was found it was at the end of each test.

In each instance these were thoroughly cleaned before engine was fired up.

Calibration of Instruments.

The steam gauge was calibrated after the test was completed and found to be correct up to 150 pounds, as the boiler pressure never

exceeded 150 pounds, the dot under zero set for 150 pounds, no corrections are necessary for the gage reading.

Indicator shows error stated by the minus sign (-) and must be added to correct.

The scale used was procured from the Mechanical Engineering department and had recently been tested and found to be practically correct.

IV Methods of Calculation.

(a) I.H.P.

The indicated Horse Power shown in table I were obtained from the formula; $I.H.P = \frac{PLAN}{33000}$.

Where

P = Mean effective pressure from cards.
L = Length of stroke in feet.
A = Area of piston in square inches.
N = Number of revolutions per minute.

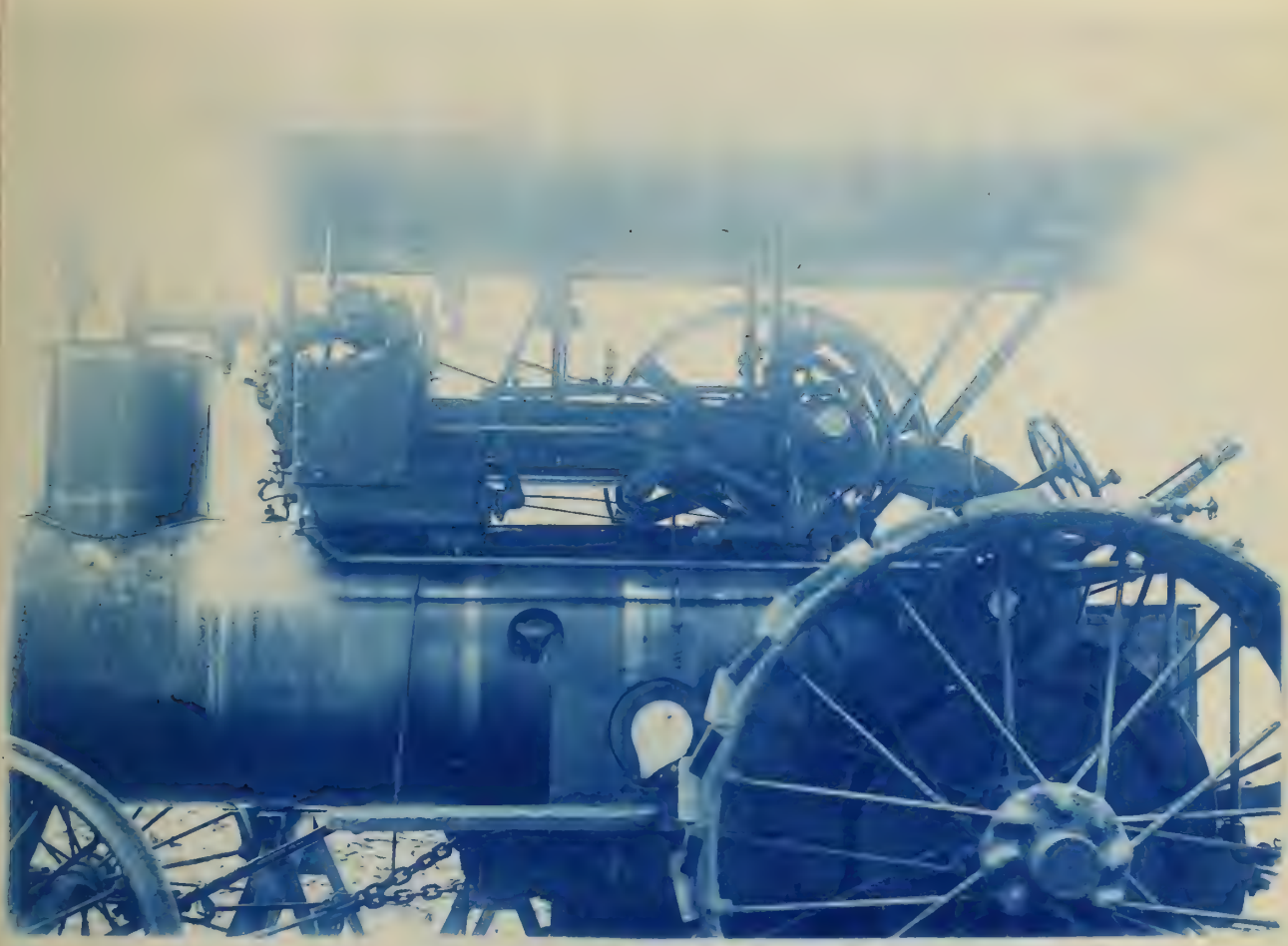
(b) B.H.P.

The Brake Horse Power shown in table I were obtained by the use of the formula;

$B.H.P = \frac{2\pi GAN}{33000}$.

Where,

G = Load on scales in pounds.
A = Brake arm in feet.
N = Number of revolutions per minute.



No	Time	M. E. P. H.P. C	M. E. P. H.P. H	M. E. P. L.P. C	M. E. P. L.P. H	R.P.M.
FEB. 24 - 1904						
1	2:05	21.0	11.[illegible]		5.[illegible]	60[illegible]
2	2:35	21.1[illegible]	11.6	7.1	[illegible]0	[illegible]
3	2:50	[illegible] 11	[illegible]7.5	1.[illegible]	1:1[illegible]	[illegible]
4	3:05	16.0	[illegible]6.3[illegible]	[illegible].01	[illegible]	[illegible]
5	3:[illegible]	16.8	[illegible]7.[illegible]	1:0	1.5	[illegible]
6	3:50	[illegible]7.0	[illegible]	1.06	[illegible]	[illegible]
7	4:00	[illegible].11	[illegible]1.4	[illegible].7	[illegible]	[illegible]
8	4:[illegible]	.0.8	1.[illegible]	[illegible]7.1	[illegible]	[illegible]
9	4:45	15.5	0.6	[illegible].5[illegible]	[illegible].	[illegible]
10	5:05	[illegible]1.06	[illegible].	[illegible].5	[illegible].	[illegible]
FEB. 25 - 1904						
1	10:10	[illegible]8.2		1[illegible].1	[illegible]6.7	[illegible]
2	10:30	[illegible]5.[illegible]	[illegible]2[illegible].2	14.[illegible]	[illegible]7.[illegible]	[illegible]
3	10:50	[illegible]7.[illegible]	[illegible]7.4		[illegible].[illegible]	[illegible]
4	11:10	[illegible].7	[illegible].5.6	14.[illegible]	[illegible].[illegible]	[illegible]
5	11:30	[illegible].1	[illegible]7.[illegible]	[illegible]5.[illegible]	16.[illegible]	[illegible]
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7	12:10	[illegible]4.0	[illegible].6.4	13.1	[illegible]-5	[illegible]
8	12:30	[illegible].5	[illegible]6.[illegible]		[illegible].[illegible]	[illegible]
9	12:50	[illegible].[illegible]	[illegible]2.7	15.[illegible]	16.7	[illegible]1
10	1:10	[illegible].5	[illegible]6.5		16.7	[illegible]
11	1:30	[illegible].[illegible]	[illegible]7.[illegible]	1.6	16.[illegible]	[illegible]
12	1:50	[illegible]+	30.[illegible]	7.5	[illegible].1	[illegible]
13	2:10	1.[illegible]	5.4	1.[illegible]	11.7	[illegible]
14	2:30	[illegible]. -	25.6	7.7	[illegible].5	[illegible]
15	2:50	[illegible].	25.[illegible]	[illegible]0.[illegible]	[illegible]. -	
16	[illegible]:10	[illegible].1	[illegible]7.+	1.[illegible]	[illegible]+.	[illegible]
17	[illegible]:30	[illegible]4.-	[illegible].[illegible]	1.4	[illegible]+[illegible]	[illegible]

No	Time	M. E. P.				R.P.M.
		H. P		L P		
		C.	H.	C.	H	
FEB. 26-1904						
1	10:30	30	[illegible]	[illegible]	[illegible]	[illegible]
2	10:50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	11.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	11:30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	11:50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	12:10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	12:30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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10	1:30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	1:50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	2:10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	2:30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	2:50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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2	10:30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	10:50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	11:10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	11:30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	11:50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	12:10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	12:30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	12:50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	1:10	16.18	15.1	7.51	[illegible]	[illegible]

No	Time	I. H. P.				R.P.M.
		H. P.		L. P.		
		C	H	C	H	
FEB 24 - 1904						
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9	[illegible]	4.80	4.07	[illegible]	[illegible]	[illegible]
10	[illegible]	4.76	[illegible]	[illegible]	[illegible]	[illegible]
FEB 25 - 1904						
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8	[illegible]	[illegible]	[illegible]		[illegible]	
9	[illegible]	[illegible]	7.40	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]		[illegible]	
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

No.	Time	I. H. P.				R.P.M.
		H. P.		L. P.		
		C	H	C	H	
FEB 26-1904						
1	10:30	5.76	6.54	5.8	6.64	24.72
2	10:50	5.94	7.12	7.06	8.3	29.07
3	11:10	6.6	7.4	6.70	7.8	28.7
4	11:30	6.50	6.8	6.60	8.1	28.1
5	11:50	6.4	7.12	5.90	7.90	27.42
6	12:10	5.9	6.9	6.70	8.0	27.51
7	12:30	6.12	7.1	6.90	7.60	27.46
8	12:50	5.7	6.4	5.74	8.0	26.06
9	1:10	5.80	7.30	5.60	7.70	27.66
10	1:30	5.6	6.4	5.70	7.50	25.16
11	1:50	5.0	5.8	5.42	6.8	23.02
12	2:10	5.38	6.06	5.31	7.47	24.72
13	2:30	5.8	5.6	5.82	7.47	24.69
14	2:50	5.60	6.1	5.90	6.9	24.13
15	3:10	5.83	6.80	5.54	6.78	24.64
16	3:30	4.7	6.50	7.40	6.77	25.40
17	3:50	5.0	5.40	5.80	7.04	23.34
FEB 27-1904						
1	10:10	4.50	5.15	4.50	5.74	19.87
2	10:30	4.83	4.60	4.06	5.45	18.21
3	10:50	4.50	5.43	4.60	5.9	20.50
4	11:10	5.80	5.89	5.83	5.71	23.07
5	11:30	4.6	5.27	5.46	5.16	19.0
6	11:50	4.83	5.40	4.13	5.42	19.83
7	12:10	3.8	4.83	3.88	5.8	17.8
8	12:30	4.6	5.03	4.0	5.2	19.1
9	12:50	4.83	4.63	4.0	5.18	18.18
10	1:10	3.9	4.28	3.4	5.72	17.8

NO.	TIME	LOAD LBS	R.P.M.	BRAKE ARM FT.	B.H.P.	STEAM PRESSURE
FEB 24-1904						
1	2:05	195	250	1.833	17	85
2	2:25	200	244	"	17	78
3	2:40	200	244	"	17.7	70
4	3:05	200	240	"	17.1	70
5	3:20	200	240	"	17.1	87
6	3:40	200	210	"	14.6	70
7	4:05	220	240	"	17.10	76
8	4:25	180	250	"	12.7	60
9	4:40	120	248	"	12	52
10	5:05	120	240	"	11.5	80
FEB. 25-1904.						
1	10:10	225	200	1.833	15.7	82
2	10:30	220	210	"	16.5	110
3	10:50	220	236	"	17.4	1.0
4	11:10	220	246	"	19.3	100
5	11:30	220	247	"	17.2	108
6	11:50	220	244	"	19.15	108
7	12:10	220	216	"	16.62	90
8	12:30	220	260	"	20.4	100
9	12:50	220	237	"	18.7	90
10	1:10	220	240	"	18.82	100
11	1:30	220	238	"	18.7	90
12	1:50	220	17-	"	13.62	70
13	2:10	220	200	"	16.1	90
14	2:30	220	218	"	17.1	104
15	2:50	220	85	"	4.72	90
16	3:10	220	211	"	16.55	14
17	3:30	220	238	"	18.15	06

NO.	TIME	LOAD LBS.	R.P.M.	BRAKE ARM FT.	B.H.P.	STEAM PRESSURE
FEB 26-1904						
1	10:30	175	204	1.833	19.6	120
2	10:50	170	225	"	21.6	115
3	11:10	170	222	"	21.3	110
4	11:30	170	218	"	20.9	110
5	11:50	170	226	"	21.7	120
6	12:10	170	222	"	21.3	114
7	12:30	175	224	"	21.5	105
8	12:50	210	238	"	20.2	115
9	1:10	210	228	"	19.9	120
10	1:30	"	229	"	20.0	115
11	1:50	"	200	"	18.1	115
12	2:10	"	222	"	19.4	105
13	2:30	"	231	"	20.2	110
14	2:50	"	212	"	18.5	110
15	3:10	"	228	"	19.9	115
16	3:30	"	221	"	19.3	120
17	3:50	"	225	"	19.4	107
FEB 27-1904						
1	10:10	175	230	1.833	14.07	115
2	10:30	"	212	"	12.9	115
3	10:50	"	235	"	14.4	105
4	11:10	"	237	"	14.5	115
5	11:30	"	236	"	14.4	120
6	11:50	"	234	"	14.3	110
7	12:10	"	237	"	14.5	110
8	12:30	"	235	"	14.4	120
9	12:50	"	234	"	14.3	110
10	1:10	"	230	"	14.0	115

No	Time	Total Coal Used	Total Coal Per. Hr.	Total Water Lbs	Total Water Per. Hr.	H_2O Per Lb Of Coal
Feb 24 - 1904						
1	2:05					
2	2:20					
3	2:45					
4	3:05		160.6		641.3	
5	3:20	482		1924		
6	3:45					
7	4:05		160.6		641.3	
8	4:20					
9	4:45					
10	5:05		160.6		641.3	3.41
Feb. 25 - 1904						
1	10:10					
2	10:30		131.1			
3	10:50					
4	11:10					
5	11:30		131.1		654.7	
6	11:50					
7	12:10					
8	12:30	704	131.1	3470	654.7	
9	12:50					
10	1:10					
11	1:30		131.1		654.7	
12	1:50					
13	2:10					
14	2:30		131.1		654.7	
15	2:50					
16	3:10					
17	3:30		131.1		654.7	4.97

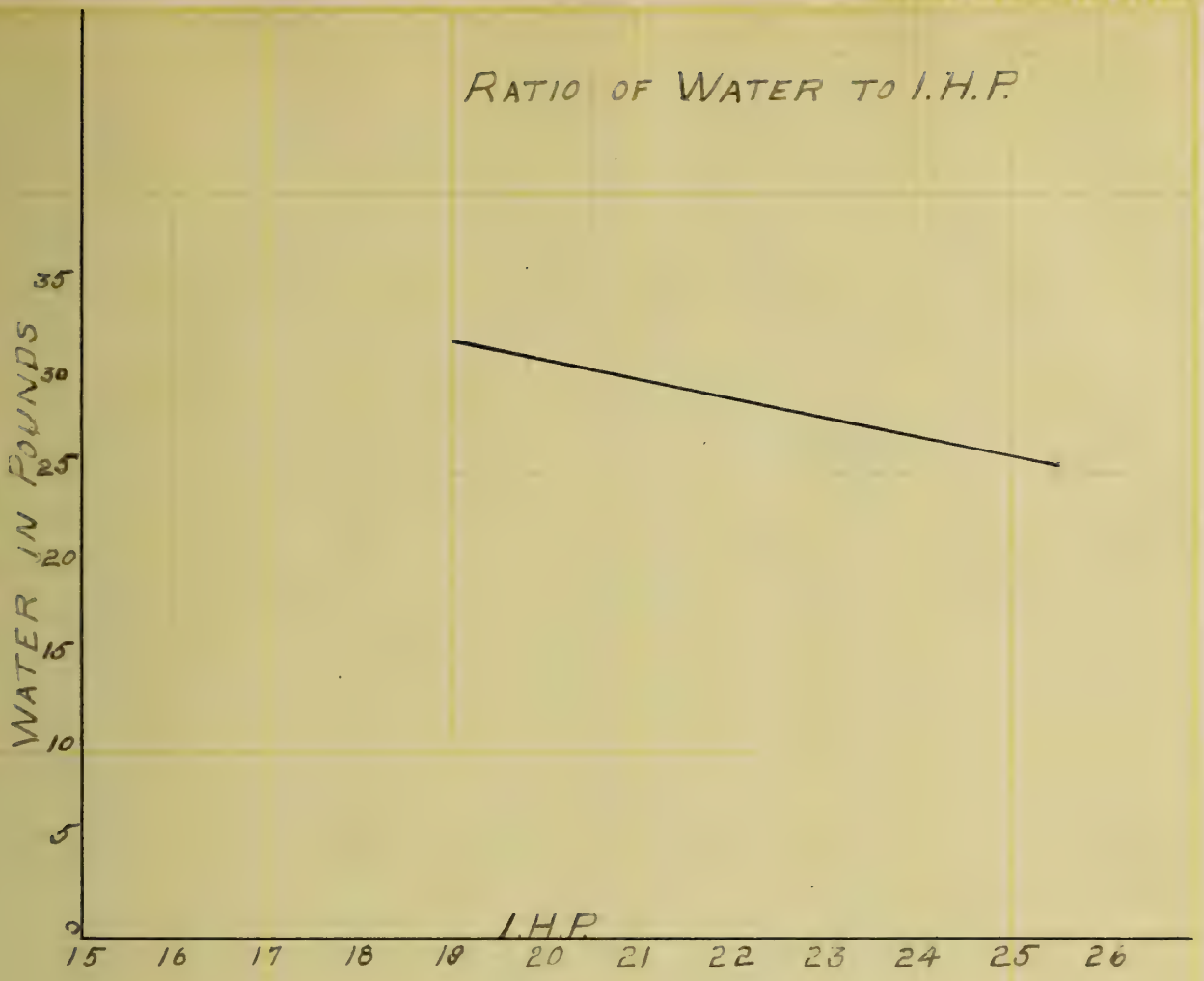
No	Time	Total Coal Used	Total Coal Per. Hr	Total Water Lbs.	Total Water Per. Hr.	H_2O Per Lb. of Coal
Feb. 26	1904					
1	10:30					
2	10:50					
3	11:10					
4	11:30					
5	11:50		164.1		640.4	
6	12:10					
7	12:30					
8	12:50		164.1		640.4	
9	1:10					
10	1:30					
11	1:50		164.1		640.4	
12	2:10					
13	2:30					
14	2:50		164.1		640.4	
15	3:10					
16	3:30					3.83
17	3:50	870	164.1	3394	640.4	
Feb 27	1904					
1	10:10					
2	10:30					
3	10:50					
4	11:10		156.5		608.5	
5	11:30					
6	11:50					
7	12:10		156.5		608.5	
8	12:30					
9	12:50					3.88
10	1:10	469.5	156.5	1820.5	608.5	

No	Time	Coal Per I.H.P.	Water Per I.H.P.	Coal Per B.H.P.	Water Per B.H.P.	Total Ash
	Feb. 26, 1904.					
1	2:05					
2	2:25					
3	2:45					
4	3:05					
5	3:25					
6	3:45					
7	4:05					
8	4:25					
9	4:45					
10	5:05	9.3	36	1.7	41.+	30
	Feb. 25 1904					
1	10:10					
2	10:30					
3	10:50					
4	11:10					
5	11:30					
6	11:50					
7	12:10					
8	12:30					
9	12:50					
10	1:10					
11	1:30					
12	1:50					
13	2:10					
14	2:30					
15	2:50					
16	3:10					
17	3:30	5.55	27.6	7.5	37.4	24

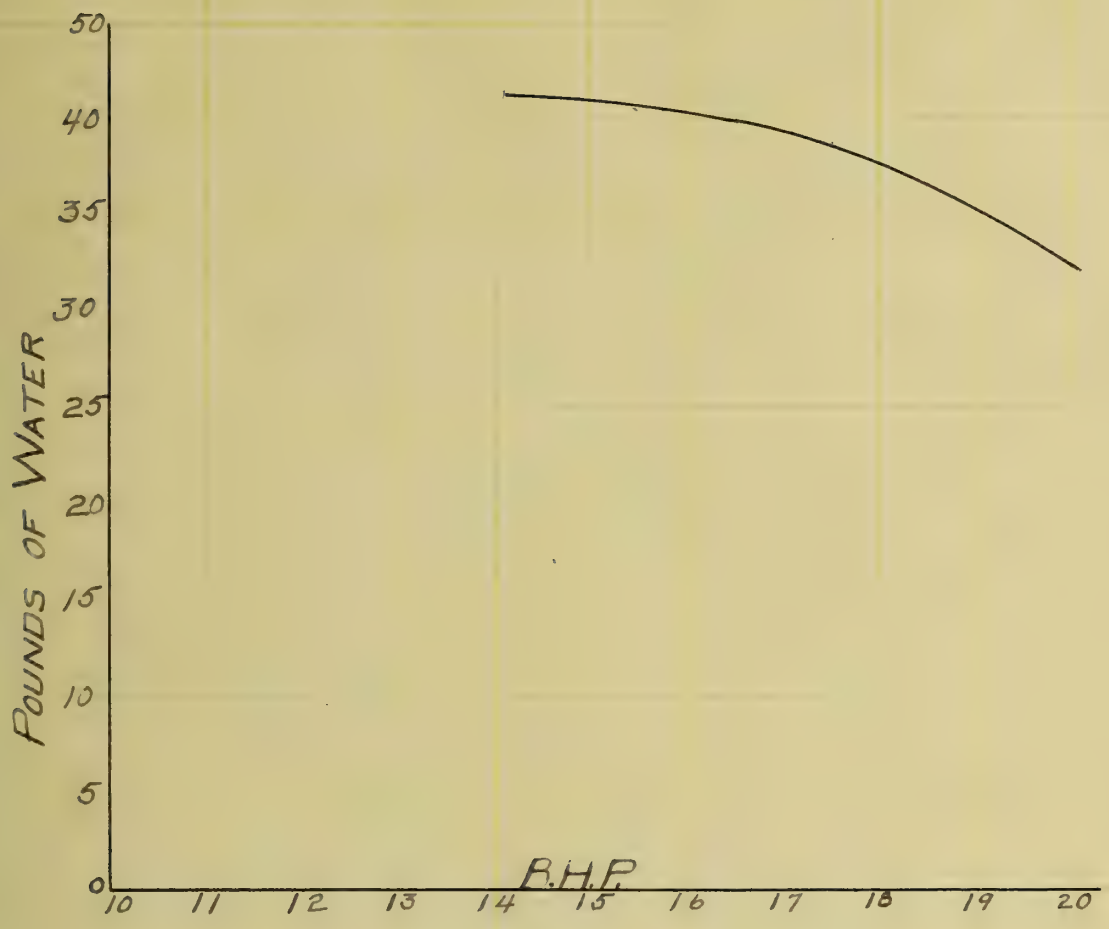
No.	Time	Coal Per I.H.P	Water Per I.H.P	Coal Per B.H.P.	Water Per BHP	Total Ash
Feb. 26	1904					
1	10:30					
2	10:50					
3	11:10					
4	11:30					
5	11:50					
6	12:10					
7	12:30					
8	12:50					
9	1:10					
10	1:30					
11	1:50					
12	2:10					
13	2:30					
14	2:50					
15	3:10					
16	3:30					
17	3:50	6.44	25.1	8.10	31.9	33
Feb. 27	1904					
1	10:10					
2	10:30					
3	10:50					
4	11:10					
5	11:30					
6	11:50					
7	12:10					
8	12:30					
9	12:50					
10	1:10	8.45	32	[illegible]	43	8

No	Time	Total H.P. H.P. Cyl.	Total H.P. L.P. Cyl	Av'ge I.H.P	Av'ge B.H.P.	Av'ge Eff.
	FEB. 26	1904				
1	10:30	12.30	12.42			
2	10:50	13.20	15.87			
3	11:10	14.01	14.70			
4	11:30	13.35	14.75			
5	11:50	13.55	13.90			
6	12:10	12.78	14.51			
7	12:30	13.26	14.20			
8	12:50	12:12	13.94			
9	1:10	12.56	13.10			
10	1:30	11.96	13.20			
11	1:50	10.84	12.24			
12	2:10	11.44	11.28			
13	2:30	11.25	13.29			
14	2:50	11.68	12.45			
15	3:10	11.62	12.62			
16	3:30	11.28	14.22			
17	3:50	10.95	12.39	25.5	20.1	79
	FEB. 27	1904				
1	10:10	9.64	10.24			
2	10:30	9.00	9.21			
3	10:50	9.95	10.45			
4	11:10	11.16	9.54			
5	11:30	9.89	9.12			
6	11:50	9.78	9.55			
7	12:10	8.13	9.68			
8	12:30	9.90	9.20			
9	12:50	8.97	9.21			
10	1:10	8.18	9.62	19	14.1	74

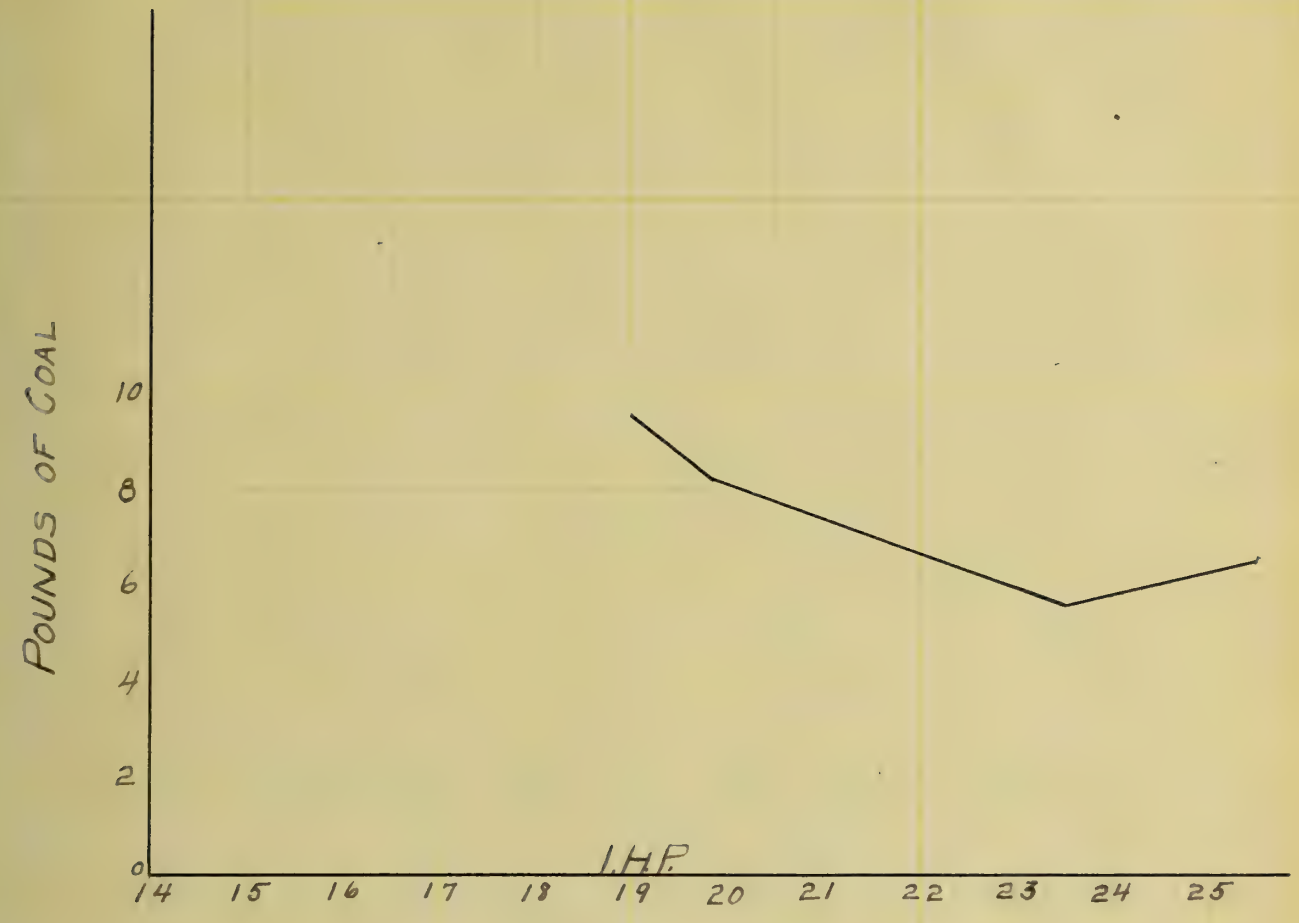
No.	Time	Total H.P. H.P. Cyl.	Total H.P. L.P. Cyl.	Av'ge I.H.P.	Av'ge B.H.P.	Av'ge Eff.
Feb. 24.	1904					
1	2:05	9.73				
2	2:25	9.69	10.10			
3	2:45	10.83	11.58			
4	3:05	12.28	9.61			
5	3:25	11.1	11.05			
6	3:45	10.09	9.2			
7	4:05	11.24	11.53			
8	4:25	8.01	7.81			
9	4:45	8.62	7.28			
10	5:05	10.16	7.42	19.8	15.5	76
Feb. 26	1904					
1	10:10		12.78			
2	10:30	12.14	10.85			
3	10:50	11.7				
4	11:10	12.94	16.11			
5	11:30	12.75	16.61			
6	11:50	11.41	14.35			
7	12:10	10.33	12.84			
8	12:30	10.95				
9	12:50	13.10	12.85			
10	1:10	11.40				
11	1:30	12.22	11.27			
12	1:50	10.16	9.06			
13	2:10	10.08	9.35			
14	2:30	10.85	10.27			
15	2:50	9.61	9.23			
16	3:10	10.22	11.50			
17	3:30	12.11	13.04	23.6	17.5	75


RATIO OF WATER TO I.H.P.
WATER IN POUNDS
35
30
25
20
15
10
5
0
I.H.P.
15
16
17
18
19
20
21
22
23
24
25
26

WATER PER B.H.P. PER HOUR

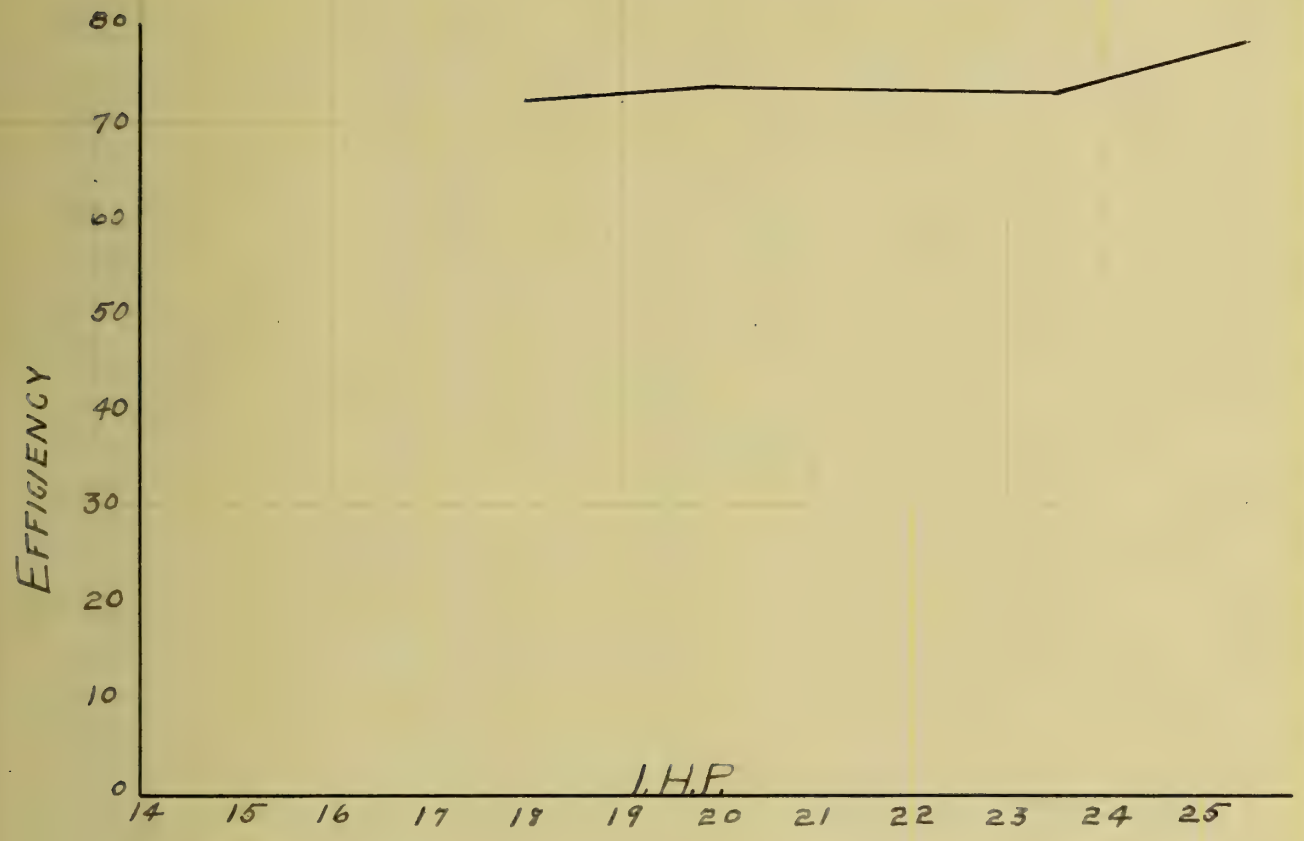


Coal per I.H.P. per Hour

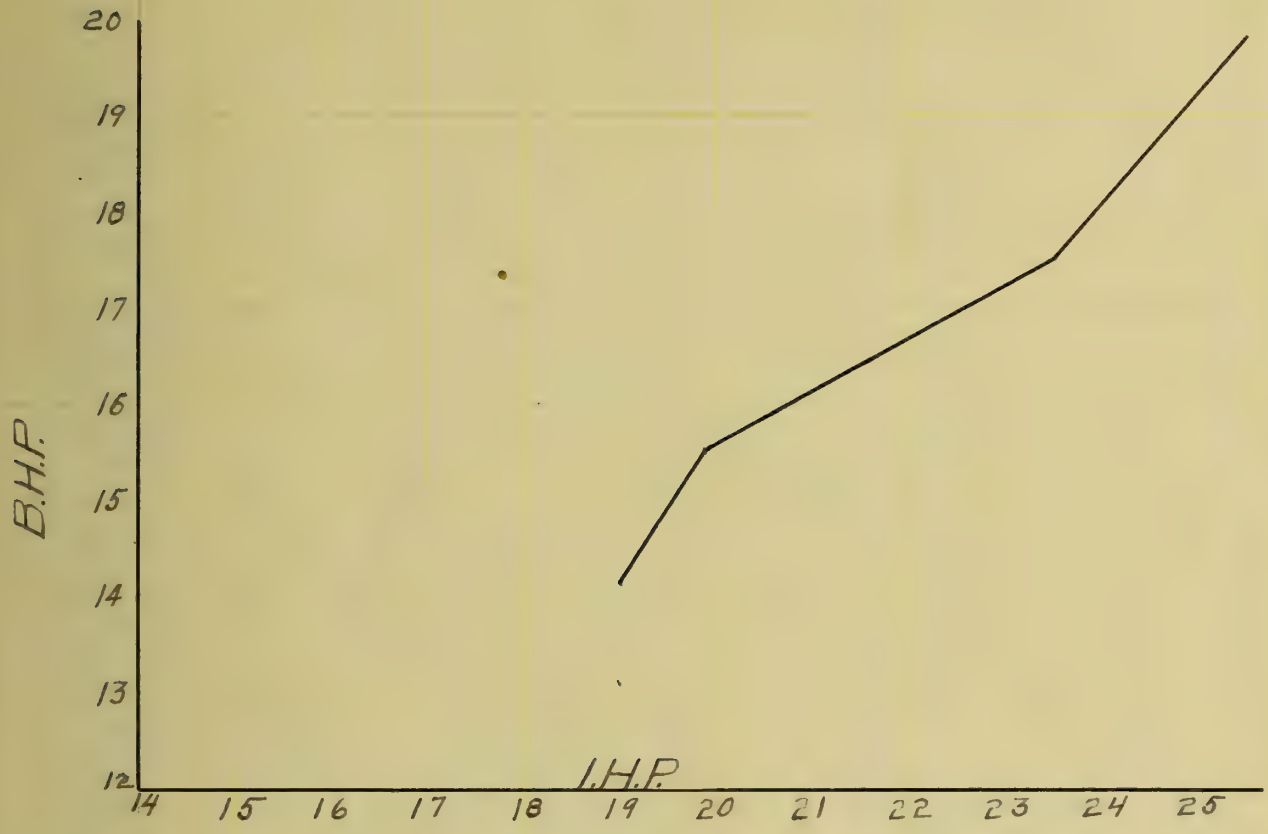


Coal per B.H.P per Hour

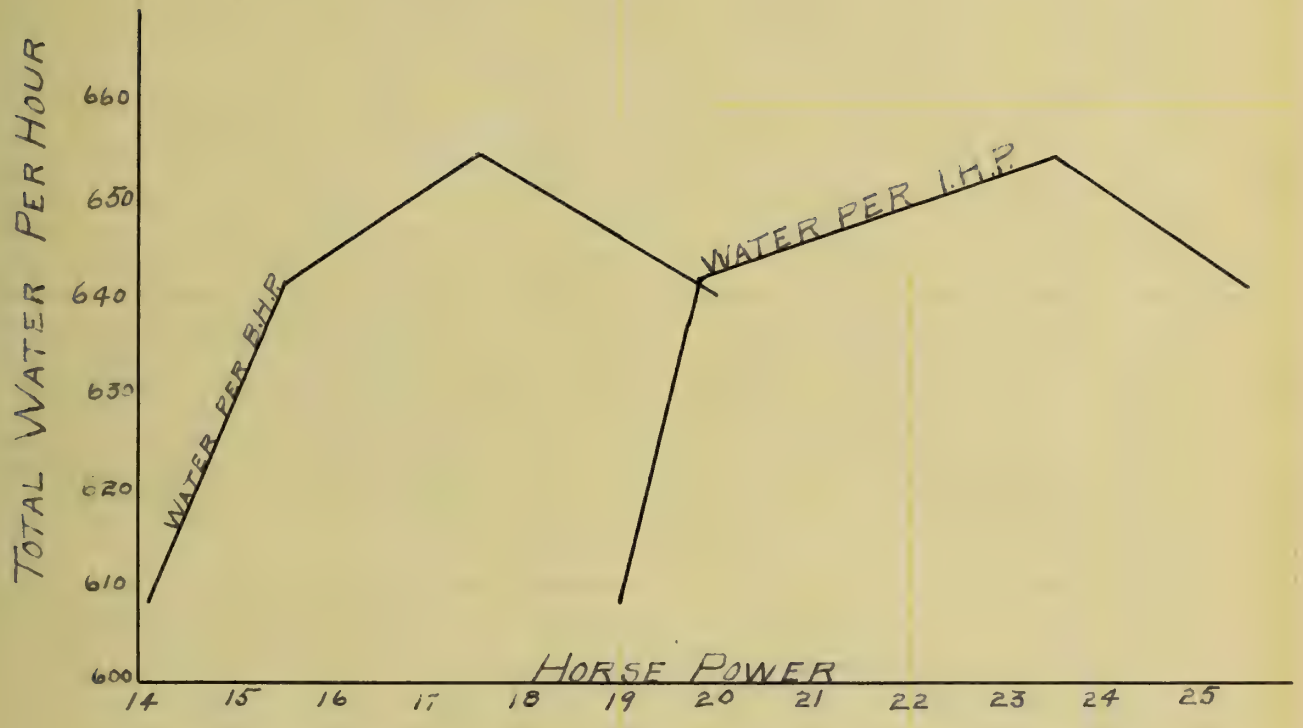
Ratio of Eff. to I.H.F.



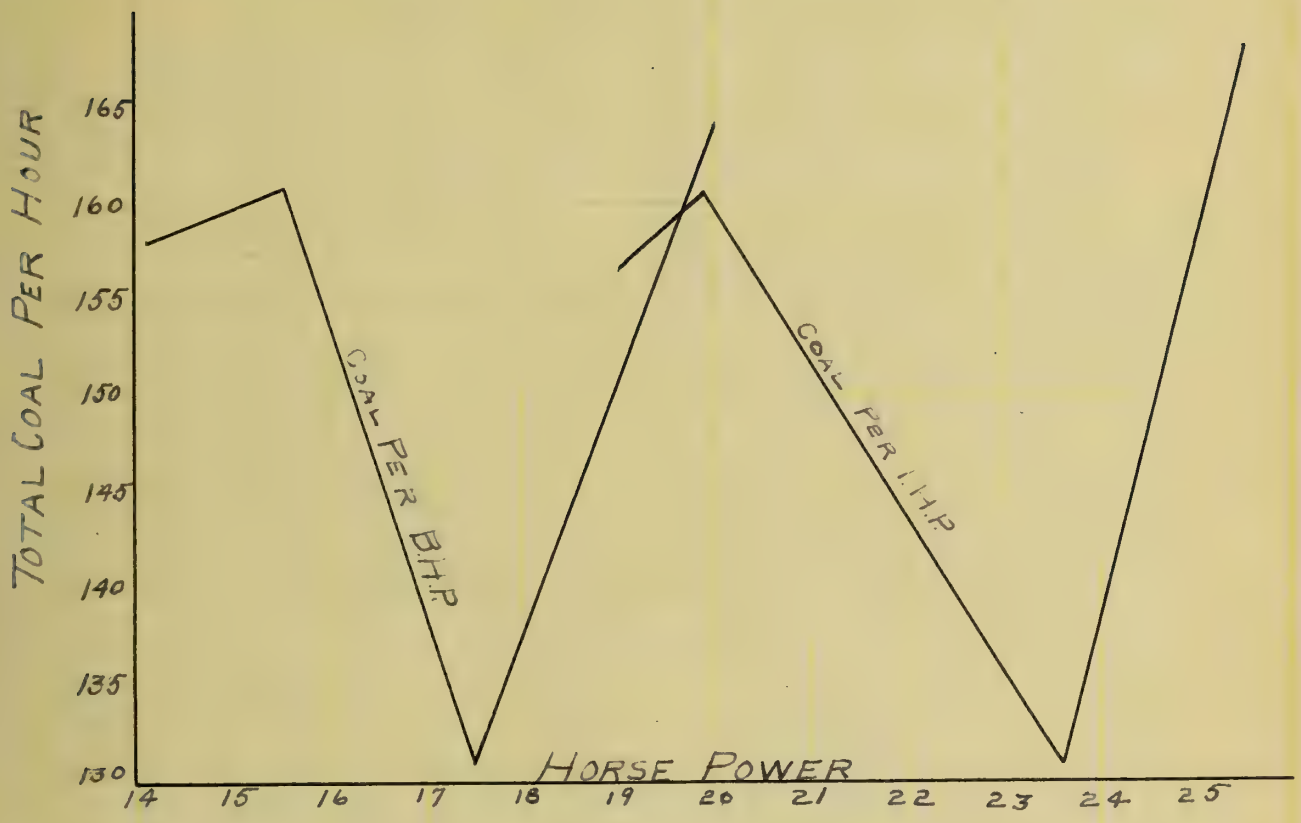
RATIO OF B.H.P. TO I.H.F.



Ratio of Total Water to H.P.



Ratio of Total Coal to H.P.



VI Discussion of Results.

(a) Average Results.

The results obtained are tabulated in condensed form in the table headed "Summary of Data and Results." The engine showed the best efficiency during a five hour test at a brake load of 265 pounds or 20 brake horse power; an over load of 25 per cent. At this load the water consumption was 31.9 pounds per B.H.P. per hour or 25.1 pounds per I.H.P. per hour.

The corresponding coal consumption was 8.16 pounds per B.H.P. or 6.44 pounds per I.H.P. per hour. Throughout the test the boiler pressure showed an average of 115 pounds.

During this test the high pressure cylinder developed an average of 12.3 and the low pressure cylinder 13.6 horse power. This difference of horse power between

the two cylinders were nearly constant for all the tests.

(b) The Curves.

The irregularity in the curve showing the ratio between the coal consumption and the horse power is very largely due to the fact that two different grades of coal were used. One a screened nut and the other a run of mine coal.

(c) Evaporation.

The four tests show an average Evaporation of 9.83 pounds of water per pound of coal.

Summary of Data

Date	I.H.P	B.H.P	# of Water to I.H.P	# of Water to B.H.P	# of Coal to I.H.P	# of Coal to B.H.P	# of Water To # of Coal	Eff.
Feb. 24, 1904	19.8	15.5	36.	41.4	8.5	10.7	3.91	.76
Feb. 25, 1904	23.6	17.5	27.6	37.4	5.55	7.5	4.07	.75
Feb 26, 1904	25.5	20.1	25.1	31.9	6.44	8.16	3.83	.79
Feb. 27, 1904	19.	14.1	32.	43	8.25	11.1	3.88	.74

Charles

Cylinder L

End H

Scale 30

LOW. PRESS

THESIS

POST AND WRIGHT

Date 2-26

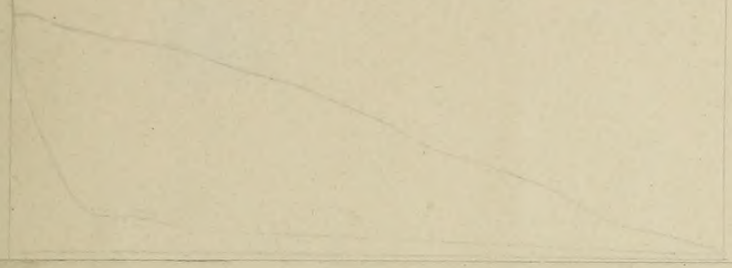
Time 11.50

R. P. M.

A. = 1.98

L. = 3.69

M. E. P. 16.1



Reeves Eng.

Cylinder Right

End Head

Scale 60#

H P.

THESIS

POST AND WRIGHT

Date 2-26-04

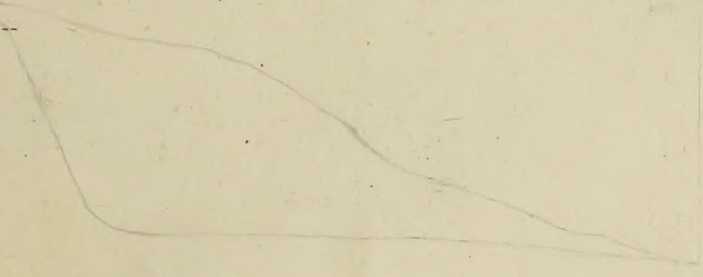
Time 1:30

R. P. M. NEB

A. = 1.78

L. = 3.64

M. E. P. 28.3



Cylinder Right

End Crank

Scale 60#

H P

THESIS

POST AND WRIGHT

Date 2-27-04

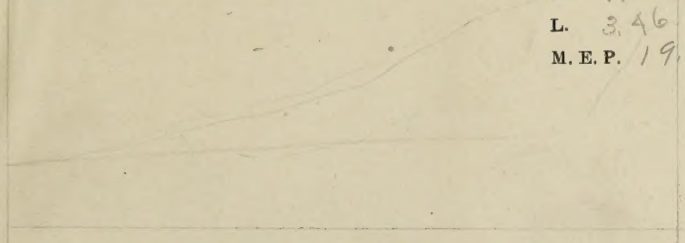
Time 11.50

R. P. M.

A. 1.12

L. 3.46

M. E. P. 19.4



Charles

Cylinder L

End C

Scale 30

L P

THESIS

POST AND WRIGHT

Date 2-25

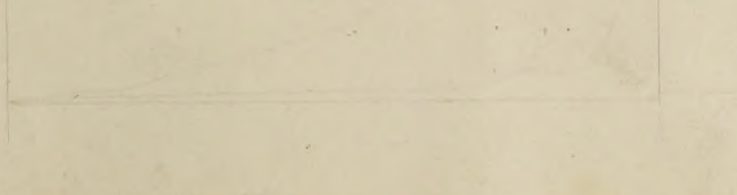
Time 2-16

R. P. M.

A. — 1.08

L. 3.37

M. E. P. 9.6



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